DOCUMENT RESUME

ED 180 744 SE 029 331

AUTHOR Spisak, Andrew W.; Maxfield, Betty D.
TITLE The Effects of Nonresponse Bias on the Results of the 1975 Survey of Doctoral Scientists and Engineers.
INSTITUTION National Academy of Sciences - National Research Council, Washington, D.C. Commission on Human Resources.
PUB DATE 79
NOTE 57p.; Contains small print in Tables and Appendices

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS College Science; Higher Education; *Manpower Utilization; Professional Personnel; Sampling; *Scientific Personnel; Scientific Research; Scientists; *Statistical Analysis; *Statistical Bias; *Surveys

ABSTRACT

This report is based on the results of the Survey of Doctoral Scientists and Engineers and the Nonresponse Bias Survey published by the Commission on Human Resources of the National Research Council in 1975. Possible biases in estimates of variables are examined. Estimates based on data from the 1975 survey respondents, plus the nonresponse bias sample, are compared with the survey's statistics, adjusted for nonresponse. Bias is examined by evaluating the differences between the two estimates. (Author/SA)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

SCOPE OF INTEREST NOTICE
The ERIC Facility has assigned this document for processing to: SE TM
In our judgement, this document is also of interest to the clearinghouses noted to the right. Indexing should reflect their special points of view.

The Effects of Nonresponse Bias on the Results of the 1975 Survey of Doctoral Scientists and Engineers

The National Research Council
(National Academy of Sciences · National Academy of Engineering · Institute of Medicine)

ED180744

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY National Academy of Sciences TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

SE 029 381

2

The Effects of Nonresponse Bias on the Results of the 1975 Survey of Doctoral Scientists and Engineers

Andrew W. Spisak
Research Associate

Betty D. Maxfield
Project Director

Comprehensive Survey of Doctorate Recipients
Commission on Human Resources
NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1979

ACKNOWLEDGMENTS

This report is based on the results of the 1975 Survey of Doctoral Scientists and Engineers and the Nonresponse Bias Survey, which were conducted under the auspices of the Commission on Human Resources (CHR) of the National Research Council. The National Science Foundation provided support for this project, and additional support from the National Institutes of Health made possible the augmentation and maintenance of the data base on the survey sample in the biomedical sciences.

Andrew W. Spisak, as principal investigator, developed the methodology for the study, drafted the report, and was responsible for incorporating reviewers' suggestions. Betty D. Maxfield, director of the Comprehensive Survey of Doctorate Recipients, assisted with the report and provided suggestions for revision. Benjamin Tepping, statistical consultant to the project, advised the project staff on survey design and sampling error calculations.

William C. Kelly, director of the Commission on Human Resources, and Dorothy Gilford, director of Human Resources Studies, provided administrative assistance and policy guidance. Lyle V. Jones served as principal reviewer for the Commission. J. James Brown of the National Science Foundation's Division of Science Resources Studies served as the staff officer at the Foundation.

Doris Rogowski supervised the activities of the CHR Supporting Services office. George Boyce, Edward J. Finan, and Donald G. Wharton of the CHR Data Processing office performed the data processing activities associated with the project. Special thanks go to Roberta Douglas, project

secretary, for her preparation of the report and to Sandra McDowell, Eileen Milner, Lori Thurgood, and Mary Wanyoike for their diligent work in locating and contacting sample members.

Appreciation goes to the many members of the scientific and engineering communities who helped in obtaining current mailing addresses for the survey sample. They include representatives of professional societies; graduate deans; academic department chairpersons; alumni office personnel; and officials in business, industry, and government.

The doctorate recipients who responded to the 1975 Survey of Doctoral Scientists and Engineers or to the Nonresponse Bias Survey deserve much gratitude for the cooperation and assistance that made this report possible.

Betty D. Maxfield
Director
Comprehensive Survey of
Doctorate Recipients

CONTENTS

Highlights vii

Introduction 1

Chapter I - 1975 Survey of Doctoral Scientists and and Engineers 3

Chapter II - Nonresponse Bias Study 9

Chapter III - Analysis of Employment Characteristics 15

Chapter IV - Analysis of Demographic Characteristics 27

Chapter V - Conclusions 33

APPENDICES

Appendix A: Questionnaire and Specialties List for the 1975 Survey of Doctoral Scientists and Engineers 37

Appendix B: Questionnaire and Cover Letters for the Nonresponse Bias Survey 43

Appendix C: Weighting Procedure 49

Appendix D: Sampling Error Estimates 53

HIGHLIGHTS

The results of the nonresponse bias study for selected variables are summarized in the following table. Generally, revised estimates of demographic and employment characteristics based on data for both respondents and nonrespondents compare favorably with estimates based solely on responses to the 1975 Survey of Doctoral Scientists and Engineers.

Comparison of Selected Statistics for U.S. Science/Engineering Ph.D.'s, Summarized

	Revised Estimate[a]	Previously Published Estimate[b]
	Total	Total
Population	262,942	279,351
Labor Force	247,561	265,534
	%	%
U.S. Science/Engineering Labor Force:		
Unemployed and Seeking Employment	1.1	1.0
Total Employed by Field:		
Mathematics	8.2	6.4
Physics/Astronomy	7.6	6.8
Chemistry	11.3	12.6
Earth, Environmental, and Marine Sciences	4.0	4.6
Engineering	15.2	15.8
Life Sciences	24.6	24.7
Psychology/Social Sciences	22.6	22.9
Full-Time and Part-Time Employed Working in:		
Business and Industry	27.7	25.9
Educational Institution	54.7	57.7
Government	10.4	10.0
Full-Time and Part-Time Employed Engaged in:		
Teaching	36.9	36.8
Research and Development	30.7	29.8
Management and Administration	19.0	20.8
U. S. Science/Engineering Population:		
Male	87.8	90.6
Female	12.2	9.4

[a]Based on results of the 1975 Survey of Doctoral Scientists and Engineers and the Nonresponse Bias Study.

[b]National Research Council, Commission on Human Resources, *Doctoral Scientists and Engineers in the United States: 1975 Profile* (Washington, D.C.: National Academy of Sciences, 1976).

The variables most affected by nonresponse bias are the sizes of the U.S. science and engineering population and labor force. Both numbers were overestimated because a much higher percentage of nonrespondents, as compared with respondents, was located outside the United States. This nonresponse bias also affected estimates for related variables such as location of B.S. institution, and citizenship.

Other variables that could be considered particularly vulnerable to nonresponse bias, such as the unemployment rate, do not appear to be substantially affected by differences between the response and nonresponse groups. Comparisons between previously published data and revised estimates for field of employment, type of employer, and primary work activity reveal only minor differences.

The revised estimate of the distribution of males and females in the U.S. science and engineering population show an apparent increase of nearly three percentage points for women and a decrease of three percentage points for men. However, this discrepancy is primarily a result of the different weighting procedures used for the 1975 survey and the nonresponse bias study, as explained in Chapter IV of the report.

The design of future surveys conducted by the Comprehensive Survey Project will incorporate the most important findings of this study. Specifically, citizenship will be added as a stratifying variable for the selection of the 1979 survey sample, to partially correct the nonresponse bias with respect to location of the population.

INTRODUCTION

In 1975 the Commission on Human Resources-National Research Council (CHR-NRC) conducted the second survey in a series of biennial surveys of a sample of Ph.D.-level scientists and engineers. The 1975 Survey of Doctoral Scientists[1] and Engineers, sponsored by the National Science Foundation (NSF) and the National Institutes of Health (NIH), provided data that, when projected to the population, yielded information about the employment and demographic characteristics of Ph.D. scientists and engineers in the United States. The results of a survey that achieves less than complete coverage of the sample are subject to nonresponse bias. If respondents and nonrespondents differ in the characteristics being studied, such bias may affect statistical results. This report analyzes the effects of bias due to nonresponse on the 1975 survey data reported in previous NRC publications.[2,3]

---

[1] Throughout this study, the population of doctoral scientists is defined as those with doctorates in the natural and social sciences and mathematics. A detailed list of fields (the Degree and Employment Specialties List) appears as part of the survey questionnaire reproduced in Appendix A.

[2] National Research Council, Commission on Human Resources, Doctoral Scientists and Engineers in the United States: 1975 Profile (Washington, D.C.: National Academy of Sciences, 1976).

[3] National Research Council, Commission on Human Resources, Employment Status of Ph.D. Scientists and Engineers: 1973 and 1975 (Washington, D.C.: National Academy of Sciences, 1976).

CHAPTER I

1975 SURVEY OF DOCTORAL SCIENTISTS AND ENGINEERS

Sampling Frame and Sample

The 1975 sample was drawn from the Roster of Doctoral Scientists and Engineers, which the National Research Council compiled from its Doctorate Records File, the NSF's National Register of Scientific and Technical Personnel, and other sources such as professional directories and catalogs of doctorate-granting institutions. The roster contained data on 314,002 individuals who either received doctorates in science or engineering between January 1, 1930, and June 30, 1974, or received Ph.D.'s in other fields during the same period and were subsequently employed in science or engineering.

The roster has several components of varying degrees of completeness. Virtually all of those awarded doctorates in science or engineering from United States institutions were included. A second segment consists of individuals who earned doctoral degrees from foreign institutions. No comprehensive sampling frame exists for foreign-earned doctorates in the United States. However, some additions were made to the 1975 sample, using college catalogs, national laboratories, and corporations as sources. A third component is the group of nonscience/nonengineering Ph.D. recipients working in science or engineering. Some 10,000 were included in 1975, approximately three percent of the roster.

The sample was stratified by field of science/engineering degree or field of science/engineering employment, year of award of the doctoral degree, degree category (i.e., recipients of science/engineering doctorates from United States institutions; recipients of nonscience/non-

engineering doctorates from United States institutions, who subsequently switched to science or engineering fields; and recipients of doctorates from foreign institutions), sex, and racial-ethnic identification (for fiscal year 1973 and 1974 Ph.D.'s only).

A variable sampling rate, ranging from 7 to 100 percent, was set for each cell in a matrix of the five stratifying variables described above, to provide samples large enough to yield reliable estimates for certain subgroups of the population (e.g., women, racial minorities, and older people). Within each cell a simple random sample was selected. Sample sizes for combined strata appear in Table 1. The 1975 sample consisted of 66,779 individuals, who represented a population of 313,992 Ph.D.'s.[4]

Survey Procedures

Previous studies and address searches revealed that of the original 66,779 individuals in the 1975 sample, 3,415 were deceased or were outside the scope of the survey. Consequently, no survey questionnaires were mailed to these former participants. (An individual is considered out-of-scope if he or she (1) holds a doctorate in a nonscience/nonengineering field and works in a nonscience/nonengineering position; or (2) holds a Ph.D. from a foreign institution, is a foreign citizen, and resides in a foreign country.) Thus, the survey sample consisted of 63,364 individuals.

The initial mailing was conducted in late May 1975, with two follow-up mailings in July and November 1975. The second follow-up mailing excluded individuals with foreign addresses except for those persons for whom new addresses had been secured. Survey data were published on responses received through March 31, 1976.

---

[4]Based on updated information, ten individuals were reassigned to six new strata prior to the 1975 survey. Because new samples were selected only from those strata comprising Ph.D. recipients who earned their degrees during the two years following the 1973 survey, these six strata were excluded from the sample selection process. This exclusion accounts for the difference between the roster total (314,002) and the total population represented (313,992).

Response Rates

Of the 63,364 individuals in the survey sample, information was collected on 43,821, yielding a response rate of 69.2 percent. The 43,821 respondents represented 74.6 percent of those who were presumed contacted (58,780). Responses were defined as not only completed questionnaires (43,442), but also information about individuals found to be deceased (379). Response rates for aggregate categories of the stratifying variables are provided in Table 1.

Among the science and engineering fields, response rates ranged from 65.0 percent for social scientists to 73.4 percent for earth scientists. Response rates were generally lower for recent Ph.D. recipients. The response rate for individuals who had earned doctorate degrees at foreign institutions was nine percentage points below the rate for Ph.D. recipients from U.S. universities. The difference is only two percentage points when the number of respondents is expressed as a percentage of the number of individuals who were presumed contacted. A lower proportion of minorities responded to the survey (57.3 percent of the sample) compared with nonminorities (69.6 percent). Nearly equal percentages of men and women, however, participated in the survey.

Data were not collected for three categories of sample members: those who refused to participate in the study (375); those for whom no valid addresses could be located (4,584); and those who were presumably contacted but failed to respond to the survey (14,584). These three types of nonrespondents, potential sources of bias in the survey results, are the subject of this report.

TABLE 1 Population, Sample, and Response Rates for the 1975 Survey of Doctoral Scientists and Engineers

	Population[a] (N)	Total Sample (N)	Inactive[b] (N)	Survey[c] Sample (N)	Survey Response (N)	Survey Deceased (N)	Non-Response (N)	Refused (N)	No Address (N)	Response Rates[d] (A) (%)	(B) (%)
TOTAL	313,992	66,779	3,415	63,364	43,442	379	14,584	375	4,584	69.2	74.6
Field of Ph.D./Employment											
Mathematics	18,645	5,011	325	4,686	3,146	27	1,191	34	288	67.7	72.1
Physics/Astronomy	27,936	5,810	216	5,594	3,797	28	1,346	33	390	68.4	73.5
Chemistry	47,276	8,821	370	8,451	5,920	47	1,771	47	666	70.6	76.5
Earth Sciences	9,759	2,194	103	2,091	1,520	15	415	19	122	73.4	78.0
Engineering	45,229	7,352	175	7,177	4,830	31	1,699	31	586	67.7	73.8
Life Sciences	79,409	19,433	713	18,720	13,252	119	3,976	96	1,277	71.4	76.7
Psychology	36,190	7,910	518	7,392	5,034	49	1,735	43	531	68.8	74.1
Social Sciences	48,275	9,397	768	8,629	5,558	55	2,321	65	630	65.0	70.2
Nonsci./Nonengr./Unknown	1,273	851	227	624	385	8	130	7	94	63.0	74.2
Year of Doctorate											
CY1930-1949	39,292	9,292	1,296	7,996	5,476	200	1,631	66	623	71.0	77.0
CY1950-FY1961	73,746	14,824	832	13,992	9,910	86	3,104	106	786	71.4	75.7
FY1962-1969	101,851	23,399	993	22,406	15,212	60	5,336	151	1,647	68.2	73.6
FY1970-1972	59,367	11,284	265	11,019	7,613	20	2,577	37	772	69.3	74.5
FY1973-1974	39,051	7,666	6	7,660	5,112	13	1,829	11	695	66.9	73.6
Unknown	685	314	23	291	119	--	107	4	61	40.9	51.7

Ph.D. Institution											
U.S.	301,431	61,453	3,152	58,301	40,396	345	13,477	311	3,772	69.9	74.7
Foreign	12,561	5,326	263	5,063	3,046	34	1,107	64	812	60.8	72.4
Sex											
Male	284,719	53,352	2,691	50,661	34,833	316	11,661	309	3,542	69.4	74.6
Female	29,273	13,427	724	12,703	8,609	63	2,923	66	1,042	68.3	74.4
Race/Ethnic Group[f]											
Minority Group	4,428	2,223	2	2,221	1,270	3	727	1	220	57.3	63.6
White/Unknown	309,564	64,556	3,413	61,143	42,172	376	13,857	374	4,364	69.6	74.9

[a]Population figures are provided for aggregate strata for each of the five stratifying variables. The sample was selected from 1,127 strata, containing a total population of 313,992.

[b]The inactive category consists of persons known to be deceased or out-of-scope prior to the 1975 survey. The out-of-scope classification was assigned to any 1973 survey respondent who indicated that he or she: 1) holds a doctorate in a nonscience/nonengineering field and works in a nonscience/nonengineering position, or 2) holds a Ph.D. degree earned at a foreign institution, is a foreign citizen, and resides in a foreign country.

[c]The survey sample consists of the total sample minus the inactive cases.

[d]Response rate "A" is the number of 1975 survey respondents plus survey deceased divided by the survey sample. Response rate "B" is the number of 1975 survey respondents plus survey deceased divided by the number assumed to have been contacted, i.e, the survey sample minus those for whom no valid addresses could be obtained.

[e]Sample members who earned doctorates in science or engineering were stratified by field of degree. Those with doctorates in the humanities, education, or professional fields who were identified as working in science or engineering were stratified by field of employment.

[f]Race/ethnic data were available from the NRC's Doctorate Records File beginning with FY1973 Ph.D. recipients. Therefore, few sample members could be classified prior to the 1975 survey.

CHAPTER II

NONRESPONSE BIAS SURVEY

Error in Sample Estimates

Estimates based on a sample are subject to two types of errors--sampling and nonsampling. Sampling error measures the precision with which an estimate based on a particular sample approximates the average result obtained from all possible samples of equal size. Nonsampling error can arise from a number of sources, including misinterpretation of survey questions, errors in coding and processing of responses, incomplete sampling frame, and bias due to nonresponse.[5]

The effects of nonresponse bias can be evaluated in a number of ways. For example, bias can be investigated by comparing the characteristics of respondents to the first survey mailing with those of respondents to follow-up mailings.[6] If the respondents to subsequent mailings report a greater proportion of unemployment than the respondents to the initial mailing, for example, bias with respect to employment status data could be inferred but could not be measured. Another approach is to assume that either all or none of the nonrespondents possess the particular characteristic being estimated. Weighting for

[5]Marie E. Gonzales et al., "Standards for Discussion and Presentation of Errors in Survey and Census Data," Journal of the American Statistical Association, 70, Part II, 1975, pp. 5-23.

[6]National Research Council, Commission on Human Resources, An Evaluation of the 1973 Survey of Doctoral Scientists and Engineers (Washington, D.C.: National Academy of Sciences, 1976).

the proportion of survey response will provide the bounds of maximum bias due to nonresponse.[7]

Both of the foregoing techniques have obvious disadvantages. The first approach makes inferences about the nonrespondents from the behavior of respondents, whereas the second approach assumes an arbitrary and empirically unsubstantiated outcome. Neither strategy is based on direct observation of the nonrespondents. In this study, data were collected for every individual in a subsample of 200 nonrespondents. Next, estimates for a number of demographic and employment characteristics were computed, on the basis of information about the respondents and nonrespondents. Finally, these estimates were compared with estimates based solely on responses to the 1975 survey, to determine whether there were important differences that would indicate nonresponse bias.

Methodology for Collection of Data on Nonrespondents

Certain demographic data were available for both respondents and nonrespondents in the 1975 survey sample, or for subgroups of the sample, from sources such as the Survey of Earned Doctorates (conducted by the CHR-NRC), the 1973 Survey of Doctoral Scientists and Engineers, and various directories, bulletins, and reference materials. Demographic data on field, year of award of doctorate, sex, location of B.S. institution, and location of Ph.D. institution were available for virtually the entire sample. Information on citizenship and age were obtained for almost all FY1958-FY1974 Ph.D.'s. Data on racial-ethnic identification were available for FY1973 and FY1974 Ph.D.'s only, and analysis of this variable was not possible because of the small number of individuals in the nonresponse subsample who earned degrees in those years.

Data on the employment characteristics of the nonresponse subsample were collected by means of a postcard questionnaire (see Appendix B). The requested information included employment status, type of employer, primary work activity, field of employment, and place of residence.

---

[7] William C. Cochran, Sampling Techniques (New York: John Wiley & Sons, Inc., pp. 361-362.

Only a few variables were selected, to limit the size of the questionnaire and, therefore, encourage individuals to respond. The selected questions were viewed as the most important items for which 1975 survey data were published. (Salary data, which might be a good measure of bias, were not collected. It was believed that the inclusion of such a sensitive item might discourage response.) All questions related to employment as of February 1975--the period with which the original survey was concerned.

The size of the subsample for the nonresponse bias study (200 individuals) was limited by the resources available to the project. A thorough analysis of nonresponse bias requires that data be obtained for virtually all individuals selected for the survey. The relatively large sampling errors associated with population estimates based on 200 observations presented limitations, which affected the design of this study.[8] For example, analyses have been restricted to comparisions of respondents and nonrespondents in terms of single variables. Multivariate analyses would create numerous small subgroups and are, tnerefore, not included in the report.

Sampling errors of the estimated differences between respondents and nonrespondents are presented in each analytical table to allow the reader to evaluate the precision of the statistics. In addition, 95 percent confidence intervals have been constructed for the revised estimates. The procedures used in weighting the 1975 survey sample and the nonresponse bias survey subsample and in estimating sampling errors are documented in Appendices C and D.

The stratified random subsample of 200 cases was selected from the 19,543 individuals for whom no data were collected in the 1975 survey (i.e., those who refused to participated in the survey, did not respond, or for whom no addresses were available). Eight subsample strata were defined in terms of field (field of Ph.D. for those with science or engineering doctorates, field of employment for nonscience or nonengineering Ph.D. recipients) and type of

---

[8]For example, the sampling error of a proportion of .5, estimated from 200 observations, is .0354. To reduce the sampling error by 50 percent, to .0177, a sample size of 800 would be required.

nonresponse, with an approximate sampling rate of one percent. The number of individuals in the 1975 sample who satisfied the nonresponse study strata definition (n) and the number of cases selected for the nonresponse bias survey subsample ($\hat{n}$) are given in Table 2.

TABLE 2 Nonresponse Bias Survey Subsample by Strata

Stratum[a]	n	$\hat{n}$
Nonresponse[b]/Refused		
Mathematics/Physical Sciences	4,856	50
Engineering	1,730	18
Life Sciences	4,072	41
Social Sciences/Other	4,301	44
No Address		
Mathematics/Physical Sciences	1,466	15
Engineering	586	6
Life Sciences	1,277	13
Social Sciences/Other	1,255	13
Total	19,543	200

[a]The stratifying variables are type of nonresponse and field, which is defined by combining strata from the 1975 sample.

[b]Those who were presumed contacted and did not respond.

Mailing Techniques

Before the first mailing of the postcard questionnaire, an intensive address search was initiated for individuals for whom no valid addresses were on file. In addition, address searches were conducted concurrently with the survey for a relatively large proportion of the subsample members, whose most recent addresses on file proved to be invalid. Numerous address sources were consulted, including the alumni offices of the individual's B.A., M.A., and Ph.D. institutions; dissertation advisors; former employers and colleagues; relatives; professional societies; numerous directories and catalogs; and publication abstracts.

Between May 1977 and June 1978, survey information was obtained for all 200 cases through four mailings, one telephone survey, contacts with relatives or colleagues, and library searches of biographic data and recent publication information.

Various mailing techniques were used in the study. The first mailing consisted of a double postcard; half contained a brief explanation of the study, and the other half comprised the five-item questionnaire. For the second and third mailings, an individually addressed cover letter accompanied the questionnaire. The cover letter provided a detailed description of the survey and stressed the importance of the individual's response to the success of the study. For the fourth mailing, cover letters were developed to appeal to both groups--those individuals with U.S. addresses and those with foreign addresses. Refer to Appendix B for the texts of the cover letters.

In all four mailings, the NRC provided return postage for individuals with U.S. addresses. International reply coupons were sent to the subsample members with foreign addresses in the fourth mailing. All letters in the fourth mailing were sent by certified mail.

Weighting and Sampling Error

Statistics in this report are weighted estimates based on sample observations. Sample weights were computed by strata and assigned to all members of the 1975 survey sample. The 200 nonresponse sample cases were weighted to equal the product of a subsample weight and sample weight computed for each of the eight strata defined in the study. To eliminate the task of rounding fractional estimates of totals, fractional weights were converted to integer weights and were randomly assigned to represent the stratum population. A detailed description of the weighting procedure and an example of the random assignment process are provided in Appendix C.

Standard errors were estimated for all statistics presented in this report. Confidence intervals are presented in the form $\hat{s} \pm (1.96 \text{ S.E. } (\hat{s}))$, where $\hat{s}$ is an estimate and S.E. $(\hat{s})$ is its standard error; 95 percent of such intervals would include the average value of the estimate obtained from all possible samples of the same design and size. Appendix D contains a detailed explanation of the method for computing sampling errors.

CHAPTER III

ANALYSIS OF EMPLOYMENT CHARACTERISTICS

On the basis of responses to its 1975 survey, the Commission on Human Resources-National Research Council published analyses of the employment characteristics of doctoral scientists and engineers in the United States.[9] Population estimates based on sample observations were weighted on the assumption that the employment characteristics of the nonrespondents were the same as those of the respondents. The validity of this assumption is doubtful; therefore, it is necessary to examine the possibility that biases may have arisen in the data because of less than complete coverage of the sample.

This section examines possible biases in estimates of variables such as the sizes of the U.S. doctoral science and engineering population and labor force, and distributions of Ph.D. scientists and engineers in the United States by employment status, type of employer, primary work activity, and employment field. Figure 1 illustrates the relationship among the population subgroups that are analyzed. Estimates, based on data from 1975 survey respondents plus the nonresponse bias sample, are compared with 1975 survey statistics, which were adjusted for nonresponse. Bias is investigated by evaluating the importance of the differences between the two estimates.

---

[9] National Research Council, Commission on Human Resources, Doctoral Scientists and Engineers in the United States: 1975 Profile (Washington, D.C.: National Academy of Sciences, 1976).

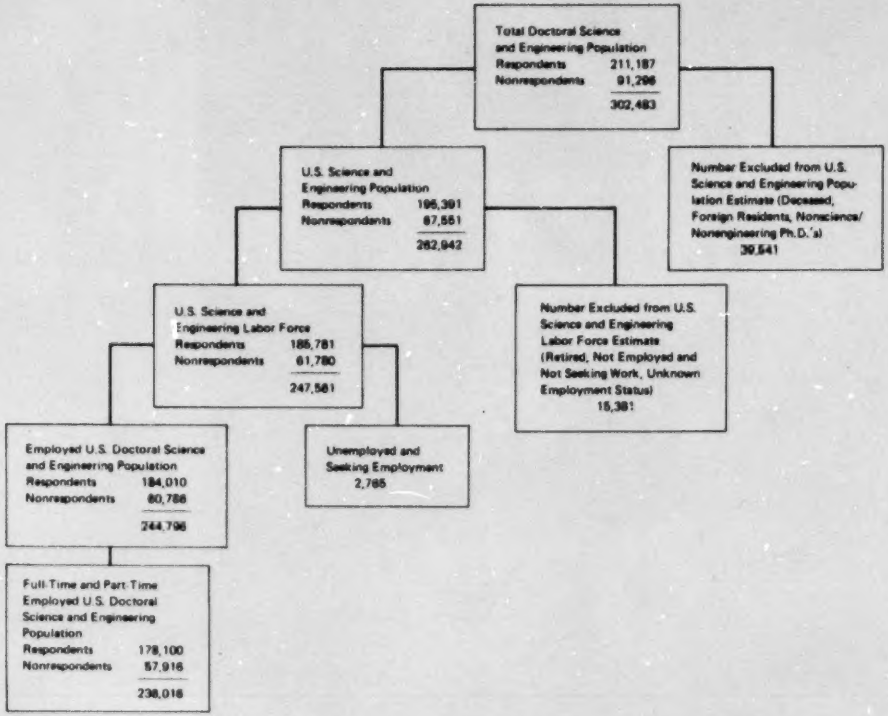

Figure 1 Population and Subpopulations of Ph.D. Scientists and Engineers

U.S. Doctoral Science and Engineering Population

Survey respondents were included in the population if they (1) had earned a doctoral degree in science or engineering between January 1, 1930, and June 30, 1974 or (2) had earned a nonscience or nonengineering degree during the same period but were employed in science or engineering in 1975. Only persons who resided or were employed in the United States during 1975 were included. Respondents having nonscience or nonengineering doctorates and working in nonscience or nonengineering fields in 1975 were excluded from the population estimate. On the basis of the 1975 survey responses, the doctoral science and engineering population in the United States in 1975 was estimated at 279,351 (±1,174).[10]

Data collected in the nonresponse bias study were used to construct a revised estimate of the U.S. science and engineering population. The number of individuals in the nonresponse bias study subsample who satisfied the criteria stated above for inclusion in the population (that is, holding a Ph.D. in science or engineering earned between January 1, 1930, and June 30, 1974, or holding a nonscience or nonengineering Ph.D. but employed in science or engineering, and residing or employed in the United States during 1975) was inflated to equal the population they represented.[11] To this figure was added the number of 1975 survey respondents who satisfied the population criteria, inflated by their sample weights (unadjusted for nonresponse).

The revised population estimate of 262,942 (±1,892) (Table 3) is nearly six percent lower than the estimate of 279,351 that was based on responses to the 1975 survey and indicates a nonresponse bias in the original estimate. Table 3 compares the response and nonresponse groups by the criteria used to define the population. Whereas 92.5 (±0.3) percent of the respondents were part of the U.S. science/engineering population, only 74.0 (±6.2) percent of the nonrespondents satisfied the criteria for inclusion in that population. Similarly, although only 6.2 (±0.2) percent

---

[10] *Ibid.*, p. 7

[11] Refer to Appendix C for 1975 weighting procedures.

of the 1975 respondents were foreign located, results of the nonresponse survey show that as many as 23.0 (±6.0) percent were located outside the United States. The difference of 16.8 (±6.0) percent between the two groups resulted in an overestimation of the U.S. science and engineering population.

TABLE 3 Population Classification of Respondents and Nonrespondents, 1975

	A Respondents[a]		B Nonrespondents[b]		S.E.(A-B)[c]	A&B Total[d]		*1975 Profile* Report Statistics
Population	211,187		91,296			302,483		e
	%	N	%	N	%	%	N	N
U.S. Science/ Engineering	92.5	(195,391)	74.0	(67,551)	3.2	86.9	(262,942)	279,351
U.S. Nonscience/ Nonengineering	0.4	(924)	1.0	(882)	0.7	0.6	(1,806)	e
Foreign Located	6.2	(13,153)	23.0	(21,010)	3.0	11.3	(34,163)	e
Deceased	0.8	(1,719)	2.0	(1,853)	1.0	1.2	(3,572)	e

[a]Population estimates based on data for all respondents to the 1975 survey (N = 43,821).

[b]Population estimates based on data for all members of the nonresponse bias survey subsample (N = 200).

[c]Sampling errors of differences between the respondents and the nonrespondents. See Appendix D for formula.

[d]Estimates based on response and nonresponse group data combined. See Appendix D for ratio and sampling error formulas.

[e]The *1975 Profile* report included estimates for the U.S. science and engineering population only.

The low response rate of Ph.D.'s located abroad may have occurred because the 1975 survey emphasized the employment characteristics of the doctoral population located in the United States. Another possible cause of underestimating the number of foreign located Ph.D.'s is that most sample members with foreign addresses were eliminated from the third mailing of the 1975 survey, when more intensive follow-up efforts were focused on the U.S. address group. The overall survey response rate increased between the second and third mailings by approximately eight percentage points, from 61.1 to 69.2 percent. Because the weighting procedure assumed no differences between respondents and nonrespondents, a greater response by the U.S. portion of the sample would result in an overestimation of that group.

Although based on a small number of observations, estimates in Table 3 for the percentages of deceased individuals and persons in the nonscience/nonengineering segment of the population are similar for both respondents and nonrespondents. Of the respondents, 0.8 (±0.08) percent

were deceased compared with 2.0 (±2.0) percent of the nonrespondents. For the response group 0.4 (±0.04) percent were classified as nonscience/nonengineering in their fields of Ph.D. and employment versus 1.0 (±1.0) percent for the nonresponse group. Because of these relatively small differences, it appears that estimates for these two categories are not substantially affected by nonresponse bias.

Employment Status

The employment status of the U.S. doctoral science and engineering population is presented in Table 4. The percentages for the response and nonresponse groups are similar for most employment categories. The largest difference is between the percentages of respondents and nonrespondents who were employed full-time, 7.3 (±6.2) percentage points. This difference suggests a possible bias attributable to nonresponse.

TABLE 4 Employment Status of Respondents and Nonrespondents in the U.S. Doctoral Science and Engineering Population, 1975

Employment Status	A Respondents[a]	B Nonrespondents[b]	S.E. (A–B)[c]	A&B Total[d]	*1975 Profile* Report Statistics
U.S. Science/ Engineering Population	195,391	67,551		262,942	279,351
	%	%	%	%	%
Full-Time Employed	88.4	81.1	3.2	86.5	88.4
Part-Time Employed	2.7	4.6	1.7	3.2	2.7
Postdoctoral Appointment	3.0	4.2	1.6	3.3	3.0
Unemployed and Seeking Employment	0.9	1.5	1.1	1.1	0.9
Not Employed and Not Seeking Employment	0.9	3.2	1.4	1.5	0.9
Retired and Not Employed	3.7	4.6	1.7	3.9	3.7
Other	0.2	e	---	0.1	0.2
No Report	0.2	0.7	0.7	0.3	0.2

[a]Population estimates based on data for those respondents to the 1975 survey who were part of the U.S. doctoral science and engineering population in 1975 (N=40,250).

[b]Population estimates based on data for those members of the nonresponse bias survey subsample who were part of the U.S. doctoral science and engineering population in 1975 (N=148).

[c]Sampling errors of differences between the respondents and the nonrespondents. See Appendix D for formula.

[d]Estimates based on response and nonresponse group data combined. See Appendix D for ratio and variance formulas.

[e]No sample members in this category.

The revised statistic of 86.5 (±1.6) percent who were full-time employed compares with the published figure of 88.4 percent.[12] Although the published estimate was affected by nonresponse bias, the overestimation of the percentage of doctoral scientists and engineers in the U.S. employed full-time was evidently small.

The data in Table 4 show that somewhat higher percentages of nonrespondents reported other than full-time employment, although for most categories the sampling errors are rather large relative to the estimated differences.

Labor Force and Unemployment Rate

The labor force consists of individuals who are full-time or part-time employed, on postdoctoral appointments, or unemployed and seeking work. The number of doctoral scientists and engineers in the U.S. labor force in 1975, estimated from the 1975 survey data, was 265,534 (±1,172).[13] The revised estimate, which includes data from the nonresponse bias survey, is 247,561 (±1,741) (Table 5). This lower labor force estimate is consistent with the preceding analysis, which indicated that published figures overestimated the size of the U.S. science and engineering population in 1975 because of the nonresponse bias favoring U.S. residents.

The estimated percentage of Ph.D.'s employed full-time is 91.9 (±1.3) percent compared with 93.0 percent reported in the 1975 Profile,[14] an insubstantial difference. There is also good agreement between the new estimates and those previously published concerning part-time employed, 3.4 (±0.9) percent, and those on postdoctoral appointments, 3.6 (±0.8) percent. The statistics computed for 1975 respondents fall

[12] National Research Council, Commission on Human Resources, Doctoral Scientists and Engineers in the United States: 1975 Profile (Washington, D.C.: National Academy of Sciences, 1976), p. 12.

[13] *Ibid.*, p. 29.

[14] *Ibid.*, p. 29.

TABLE 5 Employment Status of Respondents and Nonrespondents in the U.S. Doctoral Science and Engineering Labor Force, 1975

Employment Status	A Respondents[a]	B Nonrespondents[b]	S.E. (A–B)[c]	A&B Total[d]	*1975 Profile* Report Statistics
U.S. Science/ Engineering Labor Force	185,781	61,780		247,561	265,534
	%	%	%	%	%
Employed Full-Time	93.0	88.7	2.7	91.9	93.0
Employed Part-Time	2.9	5.0	1.9	3.4	6.0[e]
Postdoctoral Appointment	3.2	4.6	1.7	3.6	
Unemployed and Seeking Employment	1.0	1.6	1.2	1.1	1.0

[a]Population estimates based on data for those respondents to the 1975 survey who were part of the U.S. doctoral science and engineering labor force in 1975 (N=37,751).

[b]Population estimates based on data for those members of the nonresponse bias survey subsample who were part of the U.S. doctoral science and engineering labor force in 1975 (N=135).

[c]Sampling errors of differences between the respondents and the nonrespondents. See Appendix D for formula.

[d]Estimates based on response and nonresponse group data combined. See Appendix D for ratio and sampling error formulas.

[e]Respondents who were employed part-time or who held postdoctoral appointments were combined in the *1975 Profile* report.

within half a percentage point of the figures that include information on nonrespondents.

The unemployment rate, the ratio of the number of individuals who are employed and seeking work to the total labor force, is a statistic of special interest. The unemployment rate for the total doctoral science and engineering labor force, which takes into consideration both the response and nonresponse groups, is 1.1 (±0.6) percent compared with an estimated 1.0 (±0.1) percent for the respondents to the 1975 survey.[15] The small difference between the unemployment statistics is evidence that the 1975 published data were not appreciably affected by nonresponse bias.

[15] *Ibid.*, p. 29.

Field of Employment

The employment fields of respondents and nonrespondents as percentages of the total employed are shown in Table 6. For all fields, differences between estimates based on response and nonresponse data and statistics published in 1975 are small. The largest estimated difference occurs for mathematics. The 1975 Profile reported that 6.4 percent of the U.S. science and engineering population were working in this field, compared with a revised estimate of 8.2 (±1.4) percent.[16] Although the estimate for the com-

TABLE 6 Field of Employment of Respondents and Nonrespondents Employed in the United States, 1975

Employment Field	A Respondents[a]	B Non-respondents[b]	S.E. (A–B)[c]	A&B Total[d]	*1975 Profile* Report Statistics
Total Employed	184,010	60,786		244,796	262,991
	%	%	%	%	%
Mathematics/Physical Sciences	30.7	32.3	3.3	31.1	30.4
Mathematics	6.3	14.1	3.0	8.2	6.4
Physics/Astronomy	6.7	10.3	2.5	7.6	6.8
Chemistry	12.9	6.5	2.1	11.3	12.6
Earth, Environmental & Marine Sciences	4.8	1.5	1.0	4.0	4.6
Engineering	15.7	13.7	2.6	15.2	15.8
Life Sciences	25.3	22.6	2.5	24.6	24.7
Agricultural	5.0	1.3	1.0	4.1	5.0
Medical	5.2	4.0	1.5	4.9	5.1
Biological	15.1	17.2	2.6	15.6	14.6
Psychology/Social Sciences	22.1	23.9	2.5	22.6	22.9
Psychology	10.9	12.3	2.6	11.2	11.0
Social Sciences	11.2	11.6	2.5	11.3	11.9
Nonscience/Nonengineering	4.9	3.2	1.6	4.5	4.9
No Report	1.3	4.4	1.8	2.1	1.3

[a]Population estimates based on data for those respondents to the 1975 survey who were part of the employed U.S. doctoral science and engineering population in 1975 (N=37,296).

[b]Population estimates based on data for those members of the nonresponse bias survey subsample who were part of the employed U.S. doctoral science and engineering population in 1975 (N=133).

[c]Sampling errors of differences between the respondents and the nonrespondents. See Appendix D for formula.

[d]Estimates based on response and nonresponse group data combined. See Appendix D for ratio and variance formulas.

[16] *Ibid.*, p. 7.

bined response and nonresponse groups is not substantially greater than the statistic computed for respondents alone, the percentage of employed Ph.D.'s who were working in mathematics was probably slightly underestimated due to nonresponse bias.

Similarly, 11.3 (±1.0) percent of the employed Ph.D.'s were estimated to be working in chemistry compared with 12.6 percent reported in the 1975 Profile report.[17] The difference between the respondents and nonrespondents is 6.4 (±4.0) percent. Thus, the figure published in 1975 may have overestimated the percentage of doctoral scientists and engineers employed in chemistry.

Type of Employer

Data on type of employer for full-time and part-time employed doctoral scientists and engineers are presented in Table 7. Postdoctoral appointees have been excluded from the analysis, as they were in 1975, because the overwhelming proportion of this group is employed in educational institutions.

An estimated 27.7 (±2.0) percent of the full-time and part-time employed doctoral scientists and engineers were working in business and industry in 1975 compared with 25.9 percent reported in the 1975 Profile.[18] Educational institutions employed 54.7 (±2.1) percent of the scientists and engineers holding Ph.D.'s in the United States, compared with 57.7 percent reported in the 1975 published data.[19]

Bias due to nonresponse probably led to a small overestimation of the percentage employed by educational institutions and a slight underestimation of the business and industry category. The bias in favor of educational institutions may be related to the fact that fewer address sources are available for individuals working in non-academic employment.

---

[17] *Ibid.*, p. 7.

[18] *Ibid.*, p. 15.

[19] *Ibid.*, p. 15.

TABLE 7 Type of Employer of Respondents and Nonrespondents Employed in the United States, 1975 (Excluding Postdoctoral Appointees)

Type of Employer	A Respondents[a]	B Nonrespondents[b]	S.E. (A–B)[c]	A&B Total[d]	*1975 Profile* Report Statistics
Total Employed	178,100	57,916		236,016	254,643
	%	%	%	%	%
Business/Industry	26.1	32.6	4.0	27.7	25.9
Educational Institution	57.4	46.3	4.3	54.7	57.7
Government	10.1	11.1	2.7	10.4	10.0
Other	6.2	8.5	2.5	6.8	6.4[e]
No Report	0.1	1.5	1.1	0.5	

[a]Population estimates based on data for those respondents to the 1975 survey who were part of the full-time and part-time employed U.S. doctoral science and engineering population in 1975 (N=35,861).

[b]Population estimates based on data for those members of the nonresponse bias survey subsample who were part of the full-time and part-time employed U.S. doctoral science and engineering population in 1975 (N=126).

[c]Sampling errors of differences between the respondents and the nonrespondents. See Appendix D for formula.

[d]Estimates based on response and nonresponse group data combined. See Appendix D for ratio and variance formulas.

[e]The "other" and "no report" categories were combined in the *1975 Profile* report.

Primary Work Activity

With the exception of management and administration, differences between the percentages of respondents and nonrespondents engaged in various work activities are small (Table 8).

The revised statistic for management and administration, 19.0 (±1.5) percent, compared with the 1975 Profile figure of 20.8 percent, suggests a bias due to nonresponse.[20] However, as in other instances, the implications for the validity of the previously published data do not appear serious.

[20]*Ibid.*, p. 17.

TABLE 8 Primary Work Activity of Respondents and Nonrespondents Employed in the United States, 1975 (Excluding Postdoctoral Appointees)

Primary Work Activity	A Respondents[a]	B Nonrespondents[b]	S.E. (A–B)[c]	A&B Total[d]	*1975 Profile* Report Statistics
Total Employed	178,100	57,916		236,016	254,643
	%	%	%	%	%
Teaching	36.6	37.9	4.2	36.9	36.8
Research and Development	29.8	33.4	4.1	30.7	29.8
Management and Administration	20.9	13.0	3.0	19.0	20.8
Other	10.3	14.6	3.1	11.3	12.6[e]
No Report	2.4	1.0	1.0	2.1	

[a]Population estimates based on data for those respondents to the 1975 survey who were part of the full-time and part-time employed U.S. doctoral science and engineering population in 1975 (N=35,861).

[b]Population estimates based on data for those members of the nonresponse bias survey subsample who were part of the full-time and part-time employed U.S. doctoral science and engineering population in 1975 (N=126).

[c]Sampling errors of differences between the respondents and the nonrespondents. See Appendix D for formula.

[d]Estimates based on response and nonresponse group data combined. See Appendix D for ratio and variance formulas.

[e]The "other" and "no report" categories were combined in the *1975 Profile* report.

CHAPTER IV

ANALYSIS OF DEMOGRAPHIC CHARACTERISTICS

Certain demographic data for individuals in the sample were available from CHR files prior to the 1975 survey. With this information, the presence or absence of bias was investigated by comparing the estimates of the demographic characteristics of respondents and nonrespondents with estimates based only on 1975 survey response data. Variables such as sex, calendar year of Ph.D., field of Ph.D., location of B.S. institution, and location of Ph.D. institution were compared (Table 9).

Men constituted 87.8 (±1.6) percent of the doctoral-level science and engineering population in the United States compared with 12.2 (±1.6) percent for women. Based on the 1975 survey responses, estimates of 90.6 percent for men and 9.4 percent for women were reported in the 1975 Profile.[21] The rather large differences between the respondents and nonrespondents indicate a nonresponse bias that resulted in an overestimation of the number of men and an underestimation of the number of women.

It is possible, however, that the "bias" is actually a function of the different sample designs of the 1975 survey and the nonresponse bias study. Women were sampled at higher rates than men in the 1975 survey and thus carried lower weights. Because sex was not a stratifying variable in the nonresponse bias study subsample, when the original strata were aggregated and new weights assigned, the women generally received higher (and the men somewhat lower) weights than in the 1975 sample.

---

[21] *Ibid.*, p. 11.

TABLE 9 Demographic Characteristics of Respondents and Nonrespondents in the U.S. Doctoral Science and Engineering Population, 1975

	A Respondents[a]	B Nonrespondents[b]	S.E. (A–B)[c]	A&B Total[d]	*1975 Profile* Report Statistics
U.S. Science/ Engineering Population	195,391	67,551		262,942	279,351
	%	%	%	%	%
Sex					
Male	90.6	79.8	3.2	87.8	90.6
Female	9.4	20.2	3.2	12.2	9.4
Calendar Year of Ph.D.					
1930–1939	4.6	4.6	1.7	4.6	4.7
1940–1949	6.9	6.8	2.1	6.9	6.6
1950–1959	20.0	14.9	2.9	18.7	19.0
1960–1969	38.9	45.3	4.2	40.6	39.6
1970–1974	29.5	27.8	3.8	29.0	29.5
No Report	< 0.1	0.6	0.6	0.2	< 0.1
Field of Ph.D.					
Mathematics/Physical Sciences	33.7	32.7	2.1	33.4	33.4
Mathematics	5.6	8.1	2.1	6.2	5.7
Physics/Astronomy	8.9	11.4	2.4	9.5	9.0
Chemistry	15.9	11.2	2.3	14.7	15.5
Earth, Environmental, & Marine Sciences	3.4	2.0	1.2	3.0	3.2
Engineering	14.5	14.7	1.7	14.6	14.8
Life Sciences	26.0	23.8	1.9	25.4	25.2
Agricultural Sciences	4.7	3.0	1.3	4.3	4.7
Medical Sciences	2.7	4.1	1.5	3.0	2.6
Biological Sciences	18.6	16.7	2.2	18.1	17.9
Psychology/Social Sciences	23.6	24.9	2.2	24.0	24.6
Psychology	10.4	8.2	2.1	9.9	10.5
Social Sciences	13.2	16.6	2.4	14.1	14.1
Nonscience/Nonengineering	2.1	3.4	1.5	2.4	2.0
Nc Report	0.1	0.6	0.6	0.2	< 0.1
B.S. Institution Location					
United States	90.2	77.4	3.4	86.9	e
Foreign	8.1	19.1	3.2	11.0	e
No Report	1.6	3.5	1.6	2.1	e
Ph.D. Institution Location					
United States	96.5	94.1	1.8	95.9	96.0
Foreign	3.5	5.9	1.9	4.1	4.0
No Report	< 0.1	f	--	< 0.1	< 0.1

[a]Population estimates based on data for those respondents to the 1975 survey who were part of the U.S. doctoral science and engineering population in 1975 (N=40,250).

[b]Population estimates based on data for those members of the nonresponse bias survey subsample who were part of the U.S. doctoral science and engineering population in 1975 (N=148).

[c]Sampling errors of differences between the respondents and the nonrespondents. See Appendix D for formula.

[d]Estimates based on response and nonresponse group data combined. See Appendix D for ratio and variance formulas.

[e]Statistics for this variable were not published in the *1975 Profile* report.

[f]Location of Ph.D. institution is known for all nonrespondents.

This resulted in higher population estimates for women and lower population estimates for men. When the original 1975 survey sample weights are used, sex differences between respondents and nonrespondents are negligible, as shown later in this chapter. Also, the nearly identical response rates to the 1975 survey for men and women (Table 1) suggest that the differences reported in Table 9 are the result of the different weighting procedures. These procedures are detailed in Appendix C.

For calendar year of Ph.D., a somewhat higher estimate is computed from the combined response and nonresponse group data for the 1960-1969 cohort, 40.6 (±2.1) percent compared with 39.6 percent estimated from the 1975 survey response data.[22] However, the difference between the two figures does not appear to be a cause for concern.

Estimates for field of Ph.D. and Ph.D. institution location, based on aggregate data for respondents and nonrespondents, vary little from estimates computed from only the 1975 survey response data. It is important to add that because sex, field and year of doctorate, and location of Ph.D. institution were all stratifying variables for the 1975 survey sample, biases due to nonresponse were largely adjusted in the assignment of stratum weights.

Evidence of bias due to nonresponse does exist for location of B.S. institution. A much lower percentage of the nonrespondents earned B.S. degrees from U.S. institutions than did the respondents, 77.4 (±6.7) percent versus 90.2 (±0.3) percent. The combined estimate, 86.9 (±1.5) percent for the response and nonresponse groups suggests a possible overestimation of the percentage in this category. Because the foreign located Ph.D.'s were underestimated, bias with respect to location of B.S. institution would be expected in the total population of doctoral scientists and engineers. It is interesting to note that this bias also exists in the U.S. science and engineering population.

Table 10 consists of data on citizenship and age. This information was available for most individuals in the sample who earned doctorates between July 1, 1957 and June 30, 1974. Although a slightly higher proportion of the nonrespondents were over 50 years of age, the overall age distributions of respondents and nonrespondents are similar

[22] *Ibid.*, p. 11.

and support the conclusion that the effect of nonresponse bias on the estimates based on 1975 survey responses was minor.

Table 10 Citizenship and Age of Respondents and Nonrespondents in the U.S. Doctoral Science and Engineering Population, 1975 (FY1958–FY1974 Ph.D. Recipients)

	A Respondents[a]	B Nonrespondents[b]	S.E. (A–B)[c]	A&B Total[d]
U.S. Science/ Engineering Population	143,080	53,152		196,232
	%	%	%	%
Citizenship				
United States	93.7	77.1	3.9	89.2
Foreign	6.2	22.0	3.9	10.5
No Report	0.1	0.9	0.9	0.3
Age in 1975				
Under 30	5.0	4.3	1.9	4.8
30–34	28.2	26.1	4.1	27.6
35–39	27.1	23.1	4.0	26.0
40–44	19.7	22.6	4.0	20.5
45–49	11.6	11.5	2.9	11.5
50–54	5.3	6.1	2.2	5.5
55–59	2.0	2.6	1.5	2.2
60–64	0.8	e	--	0.6
Over 64	0.3	2.7	1.5	1.0
No Report	0.1	0.9	0.9	0.3

[a]Population estimates based on data for those respondents to the 1975 survey who were part of the U.S. doctoral science and engineering population in 1975 (N=29,311).

[b]Population estimates based on data for those members of the nonresponse bias survey subsample who were part of the U.S. doctoral science and engineering population in 1975 (N=116).

[c]Sampling errors of differences between the respondents and the nonrespondents. See Appendix D for formula.

[d]Estimates based on response and nonresponse group data combined. See Appendix D for ratio and variance formulas.

[e]No sample members in this category.

NOTE: Statistics for CY1930–FY1974 Ph.D. recipients in the *1975 Profile* report are not comparable with data restricted to doctorate recipients from the period FY1958–FY1974, the years for which age and citizenship information for the nonrespondents is available. The percentage distributions that would be obtained by the weighting procedure used in the *1975 Profile* are approximated by the figures in the "Respondents" column.

Citizenship data for respondents and nonrespondents follow the pattern observed for location of B.S. institution, a variable with which citizenship is presumably highly correlated. A much lower proportion of the nonrespondents held U.S. citizenship in 1975 than did respondents, 77.1 (±7.7) percent versus 93.7 (±0.3) percent.

This finding suggests that an estimate of the percentage of U.S. citizens in the doctoral science and engineering population, based entirely on response group data (93.7) percent, is subject to nonresponse bias.[23] The lower estimate of 89.2 (±2.1) percent, which takes into account information on the nonrespondents, indicates that the percentage of U.S. citizens in the U.S. science and engineering population was slightly overestimated in 1975.

Because demographic data were available for most members of the sample prior to the 1975 survey, it was possible to make comparisons between larger groups of respondents and nonrespondents than those that constituted the U.S. science and engineering population. Table 11 consists of data for those variables for which the greatest differences were observed between respondents and nonrespondents in the U.S. science and engineering population: sex, location of B.S. institution, and citizenship (for FY1958-FY1974 doctorate recipients only).

Although rather large sex differences have been observed between respondents and nonrespondents in the U.S. science and engineering population (Table 9), differences between the response and nonresponse groups in the total population appear to be practically nonexistent. This supports the hypothesis discussed earlier that this particular "bias" is actually a technical discrepancy related to the sample design and weighting.[24]

Differences between the response and nonresponse segments of the U.S. science and engineering population

---

[23] *Ibid.*, p. 11. The 1975 Profile reported that 94.2 percent of the U.S. doctoral science and engineering population were U.S. citizens. This figure included individuals who earned their Ph.D.'s between January 1, 1930, and June 30, 1974. Therefore, this statistic cannot be compared with estimates based on data for FY1958-FY1974 doctorates only.

[24] The effects of sample design and weighting on other estimates for the nonresponse group are quite small, resulting in variations of the combined estimate for respondents and nonrespondents of less than 0.5 percent.

with respect to location of B.S. institution (Table 9) and citizenship (Table 10) also appear in the total population. As expected, the nonresponse portion of the total population (which includes a greater percentage of foreign-located Ph.D.'s) consists of greater proportions of foreign citizens and doctorate recipients who earned their B.S. degrees at foreign institutions. Thus, estimates for these two variables for both the total population and the U.S. science and engineering population were probably biased due to nonresponse.

Table 11 Selected Demographic Characteristics of Respondents and Nonrespondents in the Total Doctoral Science and Engineering Population, 1975

	A Respondents[a]	B Nonrespondents[b]	S.E. (A-B)[c]	A&B Total[d]
Total Population (CY1930-FY1974 Ph.D.'s)	222,696	91,296		313,992
	%	%	%	%
Sex				
Male	90.7	90.6	0.1	90.6
Female	9.3	9.4	0.1	9.4
B.S. Institution Location				
United States	86.9	70.3	0.4	82.0
Foreign	11.4	25.7	0.3	15.5
No Report	1.8	4.0	0.1	2.4
Total Population (FY1958-FY1974 Ph.D.'s)[e]	158,057	68,658		226,715
	%	%	%	%
Citizenship				
United States	89.0	65.9	0.4	82.0
Foreign	10.9	30.5	0.4	16.8
No Report	0.1	3.6	0.1	1.2

[a]Population estimates based on data for all respondents to the 1975 survey plus those for whom information was collected prior to the 1975 survey and who were part of the total 1975 sample (N=47,236 for CY1930-FY1974 Ph.D.'s; N=33,416 for FY1958-FY1974 Ph.D.'s).

[b]Population estimates based on data for those for whom no valid addresses were available for the 1975 survey, those who refused to participate in the survey, and those who were presumably contacted but did not respond to the survey (N=19,543 for CY1930-FY1974 Ph.D.'s; N=14,698 for FY1958-FY1974 Ph.D.'s).

[c]Sampling errors of differences between the respondents and the nonrespondents. See Appendix D for formula.

[d]Estimates based on response and nonresponse group data combined. See Appendix D for ratio and variance formulas.

[e]Citizenship data were available only for FY1958-FY1974 Ph.D. recipients prior to the 1975 survey.

CHAPTER V

CONCLUSIONS

The preceding analyses indicate that the statistic most affected by bias due to nonresponse in the 1975 Survey of Doctoral Scientists and Engineers was the estimate of the size of the doctoral science and engineering population in the United States. Although 92.5 (±0.3) percent of the respondents to the 1975 survey were in the U.S. science and engineering population, only 74.0 (±6.2) percent of the nonrespondents satisfied the criteria for inclusion in the U.S. science and engineering population. The published estimate of the U.S. doctoral-level science and engineering population, based on 1975 survey responses only, was 279,351 ±1,174; the revised estimate, based on the results of this study, is 262,942 ±1,892. The revised estimate is clearly lower than the 1975 estimate. The upper bound of the 95 percent confidence interval of the revised estimate (264,834) is almost 14,000 less than the lower bound of the interval of the 1975 figure (278,177).

Of course, countervailing biases are possible, such as those resulting from the lack of a comprehensive sampling frame for individuals who hold doctorates earned at foreign institutions and who work in the United States. Investigation of such biases, which are related to nonresponse, is outside the scope of this study.

Although evidence of bias attributable to nonresponse was detected for certain employment and demographic characteristics, previously published statistics on the doctoral-level science and engineering population in the United States do not appear to have been seriously affected. This is true for the highly sensitive estimate of unemployment among Ph.D.'s. Because it is a reasonable hypothesis that an unemployed Ph.D. scientist or engineer

is less likely to respond to an employment survey, this statistic could be considered particularly vulnerable to nonresponse bias.

The 69.2 percent response rate to the 1975 survey, relative to the nonresponse rate of 30.8 percent, tends to reduce the effects of nonresponse bias. For an estimate of a particular characteristic to be seriously biased, substantial differences would have to exist between the response and nonresponse groups. For example, using the responses of 69 percent of the sample, if 25 percent of the population are estimated to be employed in business and industry, the proportion (p) of the nonresponse group working in business and industry would have to be as low as 9 percent to produce a revised estimate of 20 percent, as shown by the equation:

$$0.69\ (0.25) + 0.31(p) = 0.20$$
$$p = 0.089 \text{ or } 8.9 \text{ percent}$$

By similar calculation, the proportion of nonrespondents employed in business and industry would have to equal 0.411 or 41 percent to result in a revised estimate of 30 percent. Differences of this magnitude between the response and nonresponse groups analyzed in this study were rare.

Because a larger proportion of the nonresponse group was not part of the United States doctoral science and engineering population, the response group accounted for nearly 75 percent of the population being estimated. This increased the tolerance for differences between respondents and nonrespondents.

Although significant differences between the response and nonresponse groups were found for certain characteristics, few were sufficiently large (given the parameter being estimated and the proportion of nonresponse) to seriously affect the original estimates, which were based entirely on responses to the 1975 Survey of Doctoral Scientists and Engineers.

The findings of this study are being used in planning future surveys. The 1979 sample design has been modified to include citizenship as a stratifying variable. This change will partially adjust for differences in the response rates between individuals located in the United States and abroad and will, therefore, reduce the bias in estimates of

the sizes of the science and engineering population and labor force in the United States. Estimates for those variables similarly affected by the low response rate of sample members residing outside the United States, such as location of B.S. institution and citizenship, should be less biased as a result of the modification of the sample design.

Efforts have been made to increase both the overall response rate of 69 percent and, in particular, the participation of sample subgroups with low response rates (i.e., social scientists, mathematicians, recent Ph.D. recipients, and racial/ethnic minorities). The cover letter accompanying the 1979 survey will stress the importance of each individual's response to the success of the study. In addition, monographs of summary data from the 1977 survey were mailed to sample members in 1978 to inform them of the major findings of the previous study and to serve as a source of updated addresses.

Also, in an attempt to increase participation in the survey, the length of the 1979 questionnaire has been reduced for individuals who have responded to previous surveys. The "short form" questionnaire will eliminate those items that request previously supplied data such as sex, date of birth, and racial/ethnic group. Different mailing techniques, including certified mail and more personal cover letters and envelopes, will be tested on a small, randomly selected subsample in the follow-up mailing of the 1979 survey.

Finally, consideration will be given in future surveys to implementing a more intensive follow-up of nonrespondents. A subsample of 1,000 individuals, for example, could be randomly drawn from the group of nonrespondents and surveyed separately. Data for this group would be collected on a few key variables (such as those employment characteristics investigated in this report plus, perhaps, salary). Such a study would yield the information that is needed to evaluate the extent of nonresponse bias concurrent with the publication of survey data.

APPENDIX A

QUESTIONNAIRE AND SPECIALTIES LIST
1975 SURVEY OF DOCTORAL SCIENTISTS AND ENGINEERS

1975 SURVEY OF DOCTORAL SCIENTISTS AND ENGINEERS

OMB No. 99-R0004

CONDUCTED BY THE NATIONAL RESEARCH COUNCIL WITH THE SUPPORT OF THE NATIONAL SCIENCE FOUNDATION

THE ACCOMPANYING LETTER requests your assistance in this biennial survey of doctoral scientists and engineers – including the fields of the natural and social sciences, mathematics, and engineering.

PLEASE READ the instructions for each question carefully and answer by printing your reply or entering an 'X' in the appropriate box.

PLEASE CHECK the pre-printed information to be certain that it is correct and complete.

PLEASE RETURN the completed form in the enclosed envelope to the Commission on Human Resources, JH 638, National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

NOTE: ALL INFORMATION YOU PROVIDE WILL BE TREATED AS CONFIDENTIAL AND USED IN GROUP COMPARISONS FOR RESEARCH PURPOSES ONLY.

_____

_____

_____ (10)

If your name and address are incorrect, please enter correct information on the lines provided above. Include ZIP CODE.

If there is an alternate address through which you can always be reached, please provide it on the line below.

_____

C/O Number Street City State ZIP CODE (11)

1. Date of Birth Mo. Day Year (12-16)	2. State or Foreign Country of Birth (17-18)	3. Citizenship (19) USA 0☐ Non-USA 1☐ specify country _____ (20-21)	4. Sex (22) 1☐ Male 2☐ Female

5. Racial/Ethnic identification (23)
0☐ White/Caucasian 1☐ Black/Negro/Afro-American 2☐ American Indian 3☐ Mexican-American/Chicano 4☐ Puerto Rican-American 5☐ Oriental 6☐ Other Asian 7☐ Other, specify _____

6. List in the table below all collegiate and graduate degrees, excluding honorary degrees, that have been awarded to you. Please check the pre-printed information, including the number and name of the specialty from the list on page 3, to be certain that it is correct and complete.

Type of Degree	Granted Mo.	Granted Yr.	Major Field (Use Specialties List) Name	Major Field (Use Specialties List) Number	Institution Name	City (or campus) & State
Bachelor's						
Master's						
Doctorate						
Other, Specify						

PLEASE NOTE that in items 7-10 information is requested for both the current year, as of the week of February 9-15, 1975, and last year, as of the week of February 10-16, 1974.

7. What was your employment status as of the periods indicated? (Check only one category in each year.)

	1974	1975
Employed full-time, science or engineering related position	☐ 1	☐ 1
Employed full-time, nonscience or nonengineering related position	☐ 2	☐ 2
Employed part-time, science or engineering related position	☐ 3	☐ 3
Employed part-time, nonscience or nonengineering related position	☐ 4	☐ 4
Postdoctoral appointment (fellowship, traineeship, research associateship, etc.)	☐ 5	☐ 5
Unemployed and seeking employment	☐ 6	☐ 6
Specify number of months unemployed (66-67)		
Unemployed and not seeking employment	☐ 7	☐ 7
Retired and not employed	☐ 8	☐ 8
Specify year of retirement: (68-69)		
Other, specify _____	☐ 9	☐ 9
	(64)	(65)

7a. If you were employed full-time during February 9-15, 1975, in a position unrelated to science or engineering, what was the MOST important reason for taking the position?

	1975
Prefer nonscience or nonengineering position	☐ 1
Promoted out of science or engineering position	☐ 2
Pay is better	☐ 3
Locational preference	☐ 4
Science or engineering position not available	☐ 5
Other, specify: _____	☐ 6
	(70)

7b. If you were employed part-time during February 9-15, 1975, were you seeking full-time employment? 1☐ Yes 2☐ No (71)

Please do not write in this space

1 1 2-9 ctr # C
10 11
12 13 14 15 16
17 18 19 20 21
22 23
B
24 25 26
27 28 29
30 31 32 33 34 35
M
38 37 36
39 40 41
42 43 44 45 46 47
D
48 49 50
51 52 53
54 55 56 57 58 59
O
60 61 62 63
64 65
66 67 68 69
70 71

8. Which category below best describes the type of organization of your principal employment OR postdoctoral appointment?

(Check only one category in each year.)

	1974	1975
Business or industry	☐ 1	☐
Junior college, 2-year college, technical institute	☐ 2	☐
Medical school	☐ 3	☐
4-year college or university, other than medical school	☐ 4	☐
Elementary or secondary school system	☐ 5	☐
Hospital or clinic	☐ 6	☐
U.S. military service, active duty, or Commissioned Corps, e.g., USPHS, NOAA	☐ 7	☐
U.S. government, civilian employee	☐ 8	☐
State government	☐ 9	☐
Local or other government, specify: _____	☐ 10	☐
International Agency	☐ 11	☐
Non-profit organization, other than hospital, clinic, or educational institution	☐ 12	☐
Other, specify: _____	☐ 13	☐
	(72-73)	(74-75)

9. What were the primary (A) and secondary (B) work activities related to your position?

(Check only one box in each column.)

	1974 A	1974 B	1975 A	1975 B
Management or administration of:				
Research and development	☐	☐ 1	☐	☐
Other than research and development	☐	☐ 2	☐	☐
Both	☐	☐ 3	☐	☐
Basic research	☐	☐ 4	☐	☐
Applied research	☐	☐ 5	☐	☐
Development of equipment, products, systems, data	☐	☐ 6	☐	☐
Design	☐	☐ 7	☐	☐
Teaching	☐	☐ 8	☐	☐
Report or other technical writing, editing	☐	☐ 9	☐	☐
Production	☐	☐ 10	☐	☐
Consulting, specify: _____	☐	☐ 11	☐	☐
Professional services to individuals	☐	☐ 12	☐	☐
Quality control, inspection, testing	☐	☐ 13	☐	☐
Sales, marketing, purchasing, estimating	☐	☐ 14	☐	☐
Other, specify: _____	☐	☐ 15	☐	☐
	(10-13)		(14-17)	

10. From the Degree and Employment Specialties List on page 4, select and enter both the number and title of the scientific specialty most closely related to your principal employment or postdoctoral appointment. Write in your specialty if it is not on the list.

1974 _____ (18-20)
Number Title of Specialty

1975 _____ (21-23)
Number Title of Specialty

Please answer items 11 through 13 regarding your employment during the week of February 9-15, 1975.

11. What percent of time did you devote to each of the following activities?

	%
Management or administration of:	
Research and development	_____ (24)
Other than research and development	_____ (26)
Both	_____ (28)
Basic research	_____ (30)
Applied research	_____ (32)
Development	_____ (34)
Design	_____ (36)
Teaching	_____ (38)
Consulting	_____ (40)
Other, specify: _____	_____ (42)
TOTAL	100%

12. Please give the name of your principal employer (organization, company, etc., or, if self-employed, write "self"), and actual place of employment.

_____ (44-49)
Name of Employer

_____
Number Street

_____
City State ZIP Code (50-54)

13. What was the basic annual salary* associated with your principal professional employment during the week of February 9-15, 1975? If you were on a postdoctoral appointment (e.g., fellowship, traineeship, research associateship), what was your annual stipend plus allowances?

$_____ per year (55-57)

*NOTE: Basic annual salary is your annual salary before deductions for income tax, social security, retirement, etc., but does not include bonuses, overtime, summer teaching, or other payment for professional work.

If academically employed:

a. Check whether salary was for ☐ 9-10 months or ☐ 11-12 months. (58)

b. Did you hold a tenured position during February 9-15, 1975? 0 ☐ Yes 1 ☐ No. (59) If yes, what year was the tenure granted? _____ (60-61)

c. What is the rank of your position?

1 ☐ Professor
2 ☐ Associate Professor
3 ☐ Assistant Professor
4 ☐ Instructor
5 ☐ Lecturer
6 ☐ Dean
7 ☐ President or Chancellor
8 ☐ Other, specify: _____
9 ☐ Does not apply (62)

72 73 74 75

2 1 2-9 ctr 0

10 11 12 13

14 15 16 17

18 19 20

21 22 23

24 25 26 27 28 29

30 31 32 33 34 35

36 37 38 39 40 41

42 43

44 45 46 47 48 49

50 51 52 53 54

55 56 57

58

59

60 61

62

14. How many years of professional work experience, including teaching, have you had? _____Year(s) (63-64)

15. Have you ever held a postdoctoral appointment? 0 ☐ Yes 1 ☐ No (65)

If yes, list below the time periods of your most recent postdoctoral appointments.

Appointment	Starting Year	Total Months
Most Recent	_____ (66-67)	_____ (68-69)
Second Most Recent	_____ (70-71)	_____ (72-73)
Third Most Recent	_____ (74-75)	_____ (76-77)

How many other postdoctoral appointments have you held? _____ (78)

16. Have you ever been a full-time employee (excluding summer employment) of business or industry since earning your doctorate?

0 ☐ Yes 1 ☐ No (10)

If yes,

a. For how many years?
_____Year(s) (11-12)

b. If you were employed by business or industry in February, 1975, check here ☐. If not, how many years ago did you leave your most recent business or industry employment?
_____Year(s) (14-15)

17. Have you ever been a full-time employee (excluding summer employment) of an academic institution or organization since earning your doctorate?

0 ☐ Yes 1 ☐ No (16)

If yes,

a. For how many years?
_____Year(s) (17-19)

b. If you were employed by an academic institution or organization in February, 1975, please check here ☐. If not, how many years ago did you leave your most recent academic employment?
_____Year(s) (20-21)

18. Have you ever been a full-time employee (excluding summer employment) of government (federal, state, or local) since earning your doctorate?

0 ☐ Yes 1 ☐ No (22)

If yes,

a. For how many years?
_____Year(s) (23-24)

b. If you were employed by government in February, 1975, check here ☐. If not, how many years ago did you leave your most recent government employment?
_____Year(s) (26-27)

19. Listed below are selected topics of critical national interest. If you devoted a significant proportion of your professional time to any of these problem areas in February, 1975, please check the box for the one on which you spent the MOST time.

Education
1 ☐ Teaching
2 ☐ Other
3 ☐ Health
4 ☐ Defense
5 ☐ Environmental protection, pollution control
6 ☐ Space
7 ☐ Crime prevention and control
8 ☐ Food production and technology
9 ☐ Energy and fuel
10 ☐ Other mineral resources
11 ☐ Community development and services
12 ☐ Housing (planning, design, construction)
13 ☐ Transportation, communications
14 ☐ Other, specify: _____

(28-29)

20. Was any of your work in February, 1975, supported or sponsored by U.S. Government funds?

0 ☐ Yes 1 ☐ No 2 ☐ Don't know (30)

If yes, which of the following federal agencies or departments were supporting the work? (Check all that apply.)

31 ☐ NASA
32 ☐ National Science Foundation
33 ☐ Environmental Protection Agency
34 ☐ Energy Research & Development Administration (AEC)
35 ☐ Nuclear Regulatory Commission (AEC)
36 ☐ Agency for International Development
37 ☐ Department of the Interior
38 ☐ National Institutes of Health, HEW
39 ☐ Alcohol, Drug Abuse & Mental Health Administration, HEW
40 ☐ Office of Education, HEW
41 ☐ Other HEW, specify: _____
42 ☐ Department of Defense
43 ☐ Department of Commerce
44 ☐ Department of Agriculture
45 ☐ Department of Transportation
46 ☐ Department of Justice
47 ☐ Department of Housing and Urban Development
48 ☐ Other agency or department, specify: _____
49 ☐ Don't know source agency

63 64
65
66 67 68 69
70 71 72 73
74 75 76 77
78
3
1 2-8 ctr 0
9 10 11 12
13 14 15
16 17 18
19 20 21
22 23 24
25 26 27
28 29
30
31 32 33 34
35 36 37 38
39 40 41 42
43 44 45 46
47 48 49

DEGREE AND EMPLOYMENT SPECIALTIES LIST

MATHEMATICAL SCIENCES

- 000 - Algebra
- 010 - Analysis & Functional Analysis
- 030 - Geometry
- 050 - Logic
- 060 - Number Theory
- 063 - Probability
- 068 - Math, Statistics (see also 044, 670, 725, 728)
- 069 - Topology
- 080 - Computing Theory & Practice
- 082 - Operations Research (see also 477)
- 089 - Applied Mathematics
- 090 - Combinatorics & Finite Mathematics
- 091 - Physical Mathematics
- 098 - Mathematics, General
- 099 - Mathematics, Other*

ASTRONOMY

- 101 - Astronomy
- 102 - Astrophysics

PHYSICS

- 110 - Atomic & Molecular Physics
- 130 - Electromagnetism
- 120 - Mechanics
- 132 - Acoustics
- 134 - Fluids
- 136 - Plasma Physics
- 138 - Optics
- 139 - Thermal Physics
- 140 - Elementary Particles
- 150 - Nuclear Structure
- 190 - Solid State
- 198 - Physics, General
- 199 - Physics, Other*

CHEMISTRY

- 200 - Analytical
- 210 - Inorganic
- 215 - Synthetic Inorganic & Organometallic
- 230 - Organic
- 235 - Synthetic Organic & Natural Products
- 240 - Nuclear
- 240 - Physical
- 248 - Quantum
- 250 - Theoretical
- 256 - Structural
- 260 - Agricultural & Food
- 268 - Thermodynamics & Material Properties
- 270 - Pharmaceutical
- 275 - Polymers
- 280 - Biochemistry (see also 540)
- 288 - Chemical Dynamics
- 298 - Chemistry, General
- 299 - Chemistry, Other*

EARTH, ENVIRONMENTAL & MARINE SCIENCES

- 301 - Mineralogy, Petrology
- 308 - Geochemistry
- 310 - Stratigraphy, Sedimentation
- 320 - Paleontology
- 330 - Structural Geology
- 341 - Geophysics (Solid Earth)
- 350 - Geomorph., Glacial Geology
- 360 - Hydrology
- 370 - Oceanography
- 381 - Atmospheric Chemistry & Physics
- 382 - Atmospheric Dynamics
- 384 - Applied Geology, Odol. Engr., Econ. Geol.
- 388 - Environmental Sciences, General
- 389 - Environmental Sciences, Other*
- 397 - Marine Sciences, Other*
- 398 - Earth Sciences, General
- 399 - Earth Sciences, Other*

ENGINEERING

- 400 - Aeronautical & Astronautical
- 410 - Agricultural
- 415 - Biomedical
- 420 - Civil
- 430 - Chemical
- 435 - Ceramic
- 440 - Electrical
- 445 - Electronics
- 450 - Industrial, Manufacturing
- 455 - Nuclear
- 460 - Engineering Mechanics
- 465 - Engineering Physics
- 470 - Mechanical
- 475 - Metallurgy & Phys. Met. Engr.
- 477 - Operations Research, Systems (see also 082)
- 478 - Fuel Technology, Petrol Engr.
- 480 - Sanitary/Environmental
- 488 - Mining
- 497 - Materials Science Engr.
- 498 - Engineering, General
- 499 - Engineering, Other*

AGRICULTURAL SCIENCES

- 900 - Agronomy
- 901 - Agricultural Economics
- 902 - Animal Husbandry
- 904 - Fish & Wildlife
- 906 - Forestry
- 908 - Horticulture
- 907 - Soils & Soil Science
- 910 - Animal Sciences
- 911 - Phytopathology
- 917 - Food Science & Technology (see also 573)
- 918 - Agriculture, General
- 919 - Agriculture, Other*

MEDICAL SCIENCES

- 520 - Medicine & Surgery
- 522 - Public Health
- 533 - Veterinary Medicine
- 534 - Hospital Administration
- 537 - Parasitology
- 534 - Pathology
- 538 - Pharmacology
- 537 - Pharmacy
- 538 - Medical Sciences, General
- 539 - Medical Sciences, Other*

BIOLOGICAL SCIENCES

- 540 - Biochemistry (see also 280)
- 542 - Biophysics
- 543 - Biomathematics
- 544 - Biometrics, Biostatistics (see also 068, 670, 725, 728)
- 545 - Anatomy
- 546 - Cytology
- 547 - Embryology
- 548 - Immunology
- 550 - Botany
- 560 - Ecology
- 562 - Hydrobiology
- 564 - Microbiology & Bacteriology
- 565 - Physiology, Animal
- 567 - Physiology, Plant
- 568 - Zoology
- 570 - Genetics
- 571 - Entomology
- 572 - Molecular Biology
- 573 - Food Science & Technology (see also 517)
- 574 - Behavior/Ethology
- 578 - Biological Sciences, General
- 579 - Biological Sciences, Other*

PSYCHOLOGY

- 600 - Clinical
- 610 - Counseling & Guidance
- 620 - Developmental & Gerontological
- 630 - Educational
- 635 - School Psychology
- 641 - Experimental
- 642 - Comparative
- 643 - Physiological
- 660 - Industrial & Personnel
- 680 - Personality
- 670 - Psychometrics (see also 068, 544, 725, 728)
- 680 - Social
- 698 - Psychology, General
- 699 - Psychology, Other*

SOCIAL SCIENCES

- 700 - Anthropology
- 703 - Archeology
- 705 - Communications*
- 708 - Linguistics
- 710 - Sociology
- 720 - Economics (see also 901)
- 725 - Econometrics (see also 068, 544, 670, 728)
- 728 - Social Statistics (see also 068, 544, 670, 725)
- 740 - Geography
- 745 - Area Studies*
- 750 - Political Science, Public Administration
- 755 - International Relations
- 770 - Urban & Reg. Planning
- 778 - History & Phil. of Science
- 788 - Social Sciences, General
- 799 - Social Sciences, Other*

ARTS & HUMANITIES

- 841 - Fine & Applied Arts (including Music, Speech, Drama, etc.)
- 842 - History
- 843 - Philosophy, Religion, Theology
- 846 - Language & Literature
- 849 - Other Arts and Humanities*

EDUCATION & OTHER PROFESSIONAL FIELDS

- 838 - Education
- 857 - Business Administration
- 863 - Home Economics
- 864 - Journalism
- 866 - Speech and Hearing Sciences
- 865 - Law, Jurisprudence
- 867 - Social Work
- 871 - Library & Archival Sciences
- 888 - Professional Field, Other*

999 - OTHER FIELDS*

*Identify the specific field in the space provided on the questionnaire.

SESS2

APPENDIX B

NONRESPONSE BIAS POSTCARD QUESTIONNAIRE AND COVER LETTERS

Questionnaire and Survey Description for First Mailing

The National Research Council has recently obtained data on employment from a large stratified sample of doctorate-holders in science (including the social sciences) and engineering in the U.S. from 1930 to the present. Many individuals in government and academia have a concern about highly trained individuals in these fields who are unable to locate suitable employment.

Prior to publication of summarized data, however, we are conducting a special analysis to determine the validity of our statistics. By completing and returning the attached postcard, you will help us in evaluating our results. Thank you for your cooperation.

Betty D. Maxfield

Project Director

OMB No. 099-R0294

_____

_____

_____

If your name and address are incorrect, please enter correct information on the lines above.

1. What was your employment status as of February, 1975?
   - ☐ Employed full-time
   - ☐ Employed part-time
     Were you seeking full-time employment? ☐ Yes ☐ No
   - ☐ Postdoctoral appoir tment (fellowship, traineeship, research associateship, etc.)
   - ☐ Unemployed/seeking employment
   - ☐ Unemployed/not seeking employment
   - ☐ Retired and not employed
   - ☐ Other, specify:_____

1a. Was your place of employment/residence in February, 1975 ☐ U.S. ☐ Non-U.S.?

2. What was your primary work activity?
   - ☐ Research & Development
   - ☐ Management & Administration
   - ☐ Teaching
   - ☐ Other, specify:_____

3. Which category best describes the type of organization of your principal employment in February, 1975?
   - ☐ Business or industry
   - ☐ Two-year college
   - ☐ Medical school
   - ☐ Four-year college or university, other than medical school
   - ☐ Elementary or secondary school system
   - ☐ Hospital or clinic
   - ☐ U.S. military service
   - ☐ U.S. government, civilian employee
   - ☐ State, local, or other government
   - ☐ Non-profit organization
   - ☐ Other, specify:_____

4. What scientific specialty was most closely related to your principal employment or postdoctoral appointment?

_____

Cover Letter for Second and Third Mailings

NATIONAL RESEARCH COUNCIL
COMMISSION ON HUMAN RESOURCES
2101 Constitution Avenue Washington, D. C. 20418

July 8, 1977

Dear Dr.

In 1975 the National Research Council surveyed over 66,000 Ph.D.'s in science and engineering of which approximately 70 percent responded. Of the nonrespondents, addresses were frequently invalid, or if valid addresses were available, contacted individuals chose not to complete the questionnaire. We are now attempting to verify the results of our survey data by asking a sample of nonrespondents to answer a postcard questionnaire consisting of only four questions.

The enclosed pre-addressed postcard can be completed in a matter of seconds. Results of this special study are required as a means of measuring the accuracy of data we have collected in prior surveys. Your response is extremely important regardless of your place of residence, employment status, or field of Ph.D. or employment.

I realize that a number of demands are made on your time. Some of you, no doubt, are often asked to complete several questionnaires in the course of a year. I recognize also the growing uneasiness concerning the release of personal data. Let me assure you, however, that all responses from this survey will be held in strict confidence and that no identifying data will be released in any form. May I, therefore, receive your cooperation? A few moments of your time will be most appreciated.

Best regards,

Betty D. Maxfield

Betty D. Maxfield
Project Director
Comprehensive Survey of
Doctorate Recipients

The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering to serve government and other organizations

Cover Letter for Fourth Mailing (U.S. Address)

NATIONAL RESEARCH COUNCIL
COMMISSION ON HUMAN RESOURCES
2101 Constitution Avenue Washington, D. C. 20418

March , 1978

Dear Dr.

In 1975 the National Research Council surveyed over 66,000 Ph.D.'s in science and engineering of which approximately 70 percent responded. Of the nonrespondents, addresses were frequently invalid, or if valid addresses were available, contacted individuals chose not to complete the questionnaire. We are now attempting to verify the results of our survey data by asking a sample of nonrespondents to answer a postcard questionnaire consisting of only four questions.

The enclosed pre-addressed postcard can be completed in a matter of seconds. Results of this special study are required as a means of measuring the accuracy of data we have collected in prior surveys. Your response is extremely important regardless of your place of residence, employment status, field of Ph.D., or field of employment. Please note that the questions deal with employment information as of February 1975, the time of the original survey.

I realize that a number of demands are made on your time. I recognize also the growing uneasiness concerning the release of personal data. Let me assure you, however, that all responses from this survey will be held in strict confidence and that no information which could identify you will be released. May I receive your cooperation? A few moments of your time will be most appreciated.

Best regards,

Betty D. Maxfield
Project Director
Comprehensive Survey of
Doctorate Recipients

The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering to serve government and other organizations

Cover Letter For Fourth Mailing (Foreign Address)

NATIONAL RESEARCH COUNCIL
COMMISSION ON HUMAN RESOURCES
[illegible] Constitution Avenue Washington, D. C. [illegible]

March , 1978

Dear Dr.

In 1975 the National Research Council surveyed over 66,000 Ph.D.'s in science and engineering of which approximately 70 percent responded. Of the nonrespondents, addresses were frequently invalid, or if valid addresses were available, contacted individuals chose not to complete the questionnaire. We are now attempting to verify the results of our survey data by asking a sample of nonrespondents to answer a postcard questionnaire consisting of only four questions.

The enclosed pre-addressed postcard can be completed in a matter of seconds. Results of this special study are required as a means of measuring the accuracy of data we have collected in prior surveys. Your response is extremely important even though you may have been residing outside the United States during February 1975, the time of the original survey. Similarly, to insure the success of the study, your reply is needed regardless of your employment status, field of Ph.D., or field of employment.

I realize that a number of demands are made on your time. I recognize also the growing uneasiness concerning the release of personal data. Let me assure you, however, that all responses from this survey will be held in strict confidence and that no information which could identify you will be released. May I receive your cooperation? A few moments of your time will be most appreciated.

Best regards,

Betty D. Maxfield
Project Director
Comprehensive Survey of
Doctorate Recipients

The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering to serve government and other organizations

APPENDIX C

WEIGHTING PROCEDURE

Estimates in this report are based on weighted observations. Each individual in the 1975 survey sample (66,779) was assigned a sample weight (Ws) computed for each stratum (h) according to the formula, $Ws_h = N_h/n_h$, where N_h and n_h are the respective population and sample sizes for stratum h.

The 200 nonresponse bias sample cases received weights equal to the product of sample and subsample weights. For each stratum ($\acute{h}$) defined for the nonresponse bias survey, a sample weight ($\hat{W}s$) was computed:

$$\hat{W}s_{\acute{h}} = \frac{\sum_{h}^{H} \sum_{i}^{n_h} (Ws_{hi} \cdot y_{hi})}{\sum_{h}^{H} \sum_{i}^{n_h} y_{hi}},$$

where y_{hi} is the ith case in stratum h of the 1975 sample that satisfies the definition of stratum $\acute{h}$ in the nonresponse survey sample; Ws_{hi} is its sample weight; n_h is

the sample size of stratum h; and $\hat{H}$ is the number of strata in the 1975 sample that constitutes stratum $\hat{h}$ in the nonresponse bias survey sample.

The nonresponse subsample weights ($\hat{W}k_{\hat{h}}$) were computed by the formula $\hat{W}k_{\hat{h}} = n_{\hat{h}}/\hat{n}_{\hat{h}}$, where $n_{\hat{h}}$ is the sample size of stratum $\hat{h}$, and $\hat{n}_{\hat{h}}$ is the subsample size.

The weight for population estimate ($\hat{W}_{\hat{h}}$) is the product of the sample and subsample weights: $\hat{W}_{\hat{h}} = \hat{W}s_{\hat{h}} \cdot \hat{W}k_{\hat{h}}$.

Respondents in each stratum were assigned a weight equal to the integral part of the subsample weight, or the integral part plus one. Allocation of integral weights within a stratum were randomly allocated so as to represent the stratum population. This technique avoids the necessity of rounding fractional estimates of totals.

For example, consider a stratum which contains 56 individuals of whom 10 were selected for the sample; the average weight for the individuals in this stratum would be 56/10 = 5.6. To obtain integer weights, 4 of the respondents, chosen at random, would each receive a weight of 5, thus representing 20 individuals in the population. The 6 remaining respondents would each receive a weight of 6, thus representing 36. Combined, the 10 respondents would represent the 56 individuals in the stratum.

In this report, estimates for respondents to the 1975 survey were computed with sample weights. Referenced statistics from previous CHR publications were calculated with weights adjusted for nonresponse. These weights were obtained by dividing the stratum population (minus that portion of the population represented by the "inactive" sample members) by the number of respondents to the survey. Integer weights were assigned by the random procedure discussed above. This accounts for the small variations that occasionally occur between the ratios computed with sample weights and weights adjusted for nonresponse.

APPENDIX D

SAMPLING ERROR ESTIMATES

Most of the statistics presented in this report are ratios of random variables, $r = y/x$, where

$$y = \sum_h (N_h/n_h) \sum_i y_{hi} ,$$

$$x = \sum_h (N_h/n_h) \sum_i x_{hi} ,$$

and where y_{hi} and x_{hi} are observations made on the ith sample member of stratum h, N_h is the number of individuals in the population of stratum h, and n_h is the number of sample cases in stratum h. Strata were combined whenever the number of sample cases in a stratum was less than two.

The variance of the ratio y/x is estimated by the expression

$$s_r^2 = \left(\frac{y}{x}\right)^2 \left(\frac{s_y^2}{y^2} + \frac{s_x^2}{x^2} - \frac{2s_{xy}}{xy}\right),$$

where

$$s_{xy} \sum_h \frac{N_h^2}{n_h} \frac{N_h - n_h}{N_h - 1} \frac{1}{n_h - 1} \left(\sum_i (x_{hi} - \bar{x}_h)(y_{hi} - \bar{y}_h)\right),$$

$\bar{x}_h$ and $\bar{y}_h$ being the means of the x and y values observed in stratum h, respectively. Similarly, s_x^2 and s_y^2 are defined using $(x_{hi} - \bar{x}_h)^2$ and $(y_{hi} - \bar{y}_h)^2$ in the inner summation.

Differences between two estimated ratios in percentage form (e.g., the difference between the percentage of respondents employed by business and industry and the corresponding percentage of nonrespondents) can be expressed as $r_1 - r_2 = \frac{y_1}{x_1} - \frac{y_2}{x_2}$. The variance is estimated by $s^2_{r_1-r_2} = s^2_{r_1} + s^2_{r_2} - 2s_{r_1r_2}$. The terms $s^2_{r_1}$ and $s^2_{r_2}$ are estimated variances of ratios, calculated as given above, and $s_{r_1r_2}$ is the covariance, which, because the response and nonresponse groups do not overlap, is negligible and can be omitted from the calculation.

The estimates based on the combined data of the response and nonresponse groups are the ratios of the sums of the random variables, i.e., $r_{1,2} = y_1 + y_2 / x_1 + x_2$, where y_1 and x_1 are the estimated numbers of respondents possessing particular characteristics (for example, the number employed full-time and the number in the labor force) and y_2 and x_2 are the corresponding numbers of nonrespondents. This can also be expressed as $r_{1,2} = W \cdot r_1 + (1 - W) \cdot r_2$, where W is the proportion of the combined estimate represented by the response

group, r_1 is the ratio for the response group, and r_2 is the ratio for the nonresponse group.

The variance of the combined estimate is approximated by the sum of the variances computed for the response and nonresponse groups separately by the formula for s_r^2 discussed above, weighted for the contribution of each group:

$$s^2_{r_{1,2}} = \left[W^2 \cdot s^2_{r_1} + (1-W)^2 \cdot s^2_{r_2} \right] .$$

Again, because the response and nonresponse groups do not overlap, the covariance term has been omitted from the formula. Since estimates for the nonresponse group are based on a small number of observations that represent a large population, most of the variance is contributed by this group.

The confidence intervals presented in the text were constructed by taking the square root of the estimated variance of a statistic and multiplying this standard error by 1.96. The product was added to and subtracted from the statistic to establish the upper and lower limits of the interval.